▲ ***Ecologist Kate Kendall*** *of the U.S. Geological Survey and Glacier National Park Assistant Superintendent Butch Farabee gather grizzly bear hair samples from a passive hair trap, one of 618 set up in the greater Glacier area for the bear DNA study. The DNA gathered from these samples will allow scientists to determine and monitor bear population trends in a nonintrusive and cost-effective way.*

PARTNERS IN SCIENCE

Caring for natural resources in the national park system is a complex and often daunting responsibility that requires more scientific information sources and technical know-how than the National Park Service can rightly develop on its own. The Park Service does not conduct basic research, and certain scientific knowledge is so specialized or so specific to a locality that this expertise is better obtained elsewhere. For such needs the Park Service relies on its many partners, including other federal entities, academic institutions, nongovernmental organizations, and corporations, for their services, skills, and resources. The stories from 1998 highlight several contributions made by these science partners. They clearly illustrate the value of partnerships in deepening our understanding of complex ecosystem processes, in applying science to resource management, and in studying the relationship between people and parks.

Research Advance

SAMPLING GRIZZLIES WITH NONINVASIVE TECHNIQUES

by Katherine C. Kendall

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How do you count grizzly bears in 2 million acres of rugged, mountainous wilderness? In the Glacier National Park ecosystem (Montana, Alberta), Biological Resources Division researchers in conjunction with numerous partners are attempting to do so without capturing or even trying to see bears. Calendar year 1998 marked the start of a four-year project to monitor the grizzly bear population using noninvasive sampling and DNA fingerprinting. While conventional bear studies rely on radiotelemetry with its attendant trapping, collaring, and aerial tracking, new genetic technology now allows scientists to identify the species, sex, and individual identity of bears from small samples of hair or scat collected long after the bear has moved on.

To estimate population size, a small army of technicians was deployed on foot to install hair traps in each of 126 cells of an 8 sq km grid superimposed on maps of the study area. Bear hair traps consisted of a scent lure surrounded by a single strand of barbed wire stapled to trees. When bears passed over or under the wire to investigate the lure, they often left hair on the barbs. Fourteen days after the traps were set up, crews returned to collect the hair samples and move the traps to other sites within the cells. During five trap sessions in 1998, more than 5,500 hair samples were collected from 630 traps.

Another goal of the project is to develop a noninvasive protocol for monitoring the bear population trend that can be implemented by existing park staff. Pilot studies conducted in previous years suggest that surveys for bear scat and hair on rub trees could achieve that objective. To test this, backcountry and bear management ranger staff surveyed all 800 miles of Glacier's trails at least three times last summer. Their labors yielded 1,300 hair samples and 700 scats. Data from these samples will be used to estimate the power of bear sign surveys to detect population change.

"... new genetic technology now allows scientists to identify the species, sex, and individual identity of bears from small samples of hair or scat ..."

USGS Biological Resources Division, Kate Kendall

USGS Biological Resources Division, Mike Maples and Pete Metzger

Oblivious to a remotely operated camera, *a grizzly bear snaps its own picture while rubbing in scent lure, a putrid mix of fish and cattle blood. Although offensive to humans, the attractant is very effective at luring bears into the hair-sampling stations without providing a food reward.*

Award-Winner Profile
KATE KENDALL RECEIVES TOP RESEARCH HONOR

The 1997 Director's Award for Natural Resource Research was presented to Kate Kendall, research ecologist with the USGS Biological Resources Division, Glacier National Park. A longtime researcher in parks of the northern Rocky Mountains, Kate continually links important ecological issues to park management considerations. Much of her research has centered on the highly visible area of grizzly bear ecology. Her recent application of a noninvasive grizzly bear sampling technique, as reported in this chapter's lead story, holds potential for broad application in other parks and with other species. She is also concluding a study of the status of whitebark and limber pine communities in response to blister rust disease in Glacier, Grand Teton, and Yellowstone National Parks.

© George Scherman

Kate Kendall in grizzly bear den.

After the labor-intensive task of preparing samples for DNA extraction, the samples are sent to a genetics lab. While full analyses will require at least several more months, early results are encouraging. More than 90% of the hair samples and 80% of the scats have yielded usable DNA. Forty-five percent of the hair samples analyzed for species to date are grizzly. Once individual identities are determined, mark-recapture models will be used to estimate the population density of grizzlies in the greater Glacier ecosystem. The data will also permit evaluation of the adequacy of hair trap density in relation to the precision (confidence interval) of the population estimate.

Hands-off genetic sampling does have limitations, however. For example, the age of animals cannot be determined through genetic means, and in some cases study objectives require observing or handling animals. When dealing with small amounts of DNA such as those obtained from scat samples, duplicate analyses must be run to obtain reliable results. The possibility always exists that some bears will not be attracted to the traps, which can cause errors in density estimates. However, DNA fingerprinting with subsequent intensive monitoring can provide defensible data on absolute minimum numbers and demographics of grizzly bears using an area—all without ever having to *see* them, much less trap and mark them!

Whether estimating population size, trend, or genetic fitness, noninvasive genetic methods hold enormous potential for surveying other elusive forest carnivores and sensitive species. Genetic sampling can provide unequivocal information needed for resource stewardship. For instance, it can be employed to establish the presence of rare animals where this was impractical in the past. Not only are noninvasive techniques less stressful to study subjects, but they also help preserve the solitude and untrammeled character of national parks. Genetic sampling is bound to become an important inventory, monitoring, and research tool in natural areas in the future.

Named for the smoke-like haze *that envelops the woodlands and hollows, Great Smoky Mountains National Park is the location of an ambitious scientific undertaking—the world's first inventory of all forms of life in a discrete area. The project is expected to take about a decade and will involve numerous partners.*

INVENTORY OF BIODIVERSITY TAKES SHAPE IN THE SMOKY MOUNTAINS GPRA

by Becky Nichols

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The assemblages of living organisms in Great Smoky Mountains National Park in Tennessee and North Carolina are some of the richest and most diverse in the temperate world. New taxa are routinely discovered not only by scientists but also by the public. For example, a trail maintenance worker recently discovered a new species of earthworm on the Appalachian Trail. Nevertheless, formal inventories have not been comprehensive, and fewer than 10,000 (10%) of an estimated 100,000 faunal and floral species are known in the park.

Existing and impending threats in the park region include invasion by exotic species, air pollution, and forest diseases. Protection of natural resources from these threats requires advanced management techniques that are enhanced by information on the identity and status of the species. This need for information precipitated the inception of an All Taxa Biodiversity Inventory.

The inventory will be comprehensive and include all life-forms. On 24 April 1998 at the Twin Creeks Natural Resources Center in Gatlinburg, Tennessee, the park made a formal announcement of the multi-year project. Deputy Director Deny Galvin of the National Park Service, many other officials and scientists from a broad range of disciplines, and local and national media attended the meeting. The inventory is expected to take 10–15 years and will be funded through the volunteer science and education organization Discover Life in America. This nonprofit group consists of a variety of public and private financial sources, including Friends of the Great Smoky Mountains National Park and the Great Smoky Mountains Natural History Association. The park and the organization will form a cooperative agreement to conduct the inventory, which will begin with a two-year pilot study.

In May 1998 the board of directors held its first meeting and adopted the draft by-laws and elected officers. A website was developed at www.discoverlife.org. This site gives details about the mission and recent activities and offers opportunities for involvement by the public. The Natural History Association assisted with the development of a brochure about the inventory.

More than 100 scientists, managers, educators, and other interested individuals attended a general planning workshop on 14–17 December 1998 in Gatlinburg. The main goal of the workshop was the development of plans for the pilot study. The participants addressed sampling design, collecting protocols, databases, fund-raising, sorting and curation of specimens, website development, communications and public relations, facilities planning, and educational programs. Pilot sampling will begin in spring 1999. Protocols and design will be refined during this time. The comprehensive phase of the inventory is expected to last for about a decade.

Blue Ridge spring salamander, © 1995 Steve Tilley

Driven by a sense of urgency, *the All Taxa Biodiversity Inventory seeks to document the Great Smoky's exceptional biodiversity, including salamander species, before some of it is lost to threats such as air pollution, exotic species, and urbanization. Since the project began, a new worm species has been discovered and numerous invertebrate finds are anticipated.*

TNC OFFERS TRAINING

Under contract to the National Park Service, The Nature Conservancy offered its training course "Vegetation Monitoring in a Management Context" to 21 NPS participants in June 1998. The course met with rave reviews for its value in providing a scientific basis for preparing an inventory and monitoring plan.

The 1988 fires *provided an opportunity to study forest recovery in Yellowstone. Vegetation growth in the Twin Lakes study plot (left), where soils are rhyolitic, covered only about 25% of the ground three years after the burn; 10 years after the fires, 60–90% of the ground was covered. In contrast, plants in the Petrified Tree plot (right), where soils are andesitic, covered 100% of the site just one year after the burn. This response is typical for vegetation growing on the volcanic andesitic soils, especially at lower elevations (< 7,600 feet above sea level).*

GEOLOGY SIGNIFICANT IN DETERMINING VEGETATION GROWTH IN YELLOWSTONE

by Don G. Despain

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The 10th anniversary of the great 1988 fires in Yellowstone National Park (Wyoming, Montana, Idaho) has allowed researchers with the Biological Resources Division (BRD) to draw some conclusions about their studies of the fires' aftermath. They have found that the ecosystem was not destroyed by the flames and that the growth of vegetation has varied in some fascinating ways—even being effected by the type of bedrock beneath the regenerating plants.

In permanently marked plots, researchers found that numerous seeds were already buried deep enough in the soil to escape the heat. Melting snows in spring 1989 brought them to life. Rhizomes and other underground plant parts also sprouted and the ground was quickly covered with vegetation. The amount of growth, the species diversity, and the species growing within the research plots were affected more by the elevation of the sites and the characteristics of the soil derived from different rock types than by differences in fire intensity. Soils derived from the basic andesitic (volcanic) rocks are higher in plant nutrients and water-holding capacity. Those derived from the acid rhyolitic (also volcanic, but higher in silica) rocks are lower in both of those categories.

After 10 years, plots on andesitic soils had a thick ground cover with plants overlapping to cover 120–140% of the surface. On the rhyolitic soils, cover was only 35–90%, but even this was greater than the prefire ground cover of 20–60%. Douglas-fir seedlings predominated on the low-elevation andesitic sites, while lodgepole pine dominated at higher elevations and on all the rhyolitic sites. On average, 20 to 25 different species per plot were documented on andesite, while only 12 to 17 species occurred on the rhyolitic sites. Plants grew faster on the warmer, lower elevations, and a given level of plant cover was reached earlier than on higher elevations. Some flowers and grasses, such as dragon's tongue and heart-leafed arnica, did better in the early years and became less conspicuous as time went on, while others, such as pine grass and showy aster, steadily increased. Seeds of two species that had not been frequently observed in the park were waiting in the soil for the fires. Shiny-leaf ceanothus seeds sprouted and began a shrub

SCIENCE INFORMATION SHARED

The Biological Resources Division unveiled its Science Information Service (SIS) on the World Wide Web in 1998. This new tool helps put managers and researchers in touch with one another by making available research abstracts on 1,800 research projects relevant to park resources. It can be accessed on the web by clicking on "Current Projects (SIS)" at http://biology.usgs.gov.

layer that will last for a century or more before it will be shaded out by the now tiny Douglas-fir trees. Bicknell's geranium seeds also responded to the heated soil; however, as a biennial it did not last very long before retreating to the cover of the soil to await the next fire, perhaps another 250 years from now.

Throughout the research, Geographic Information Systems have proven to be important for correlating the differences in recovery of vegetation with the different soils. The bedrock geology map of the park was overlain by a map showing the extent of the burn and a map showing the extent and location of the different vegetation responses. Made available to the park by BRD researchers, this map provides a visual representation of places where one would expect to see these different effects. The information will also be useful to researchers studying fire effects, such as those who look at landscape-level effects, those who follow changes in animal distribution and population status, and stream ecologists and hydrologists.

Global Climate Change

GLACIER NATIONAL PARK CLIMATE CHANGE RESEARCH DELIVERS INSIGHTS

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People are more aware than ever that global climate changes are taking place. What do these changes mean for national parks, and what is their role in the preservation of park natural resources? To answer such questions, the Department of the Interior began a broad program of global climate change research in the late 1980s. Since 1989 an interdisciplinary team from the U.S. Geological Survey, National Park Service, U.S. Forest Service, and University of Montana has conducted research at Glacier National Park (Montana) with the primary objective of understanding how this 1.1 million–acre mountain wilderness responds to the present climate so that impacts of future climate change can be predicted.

Over nine years this research team has increased the sophistication of predictive computer models, which organize available information about this complex ecosystem and, in computer code, represent known ecological relationships. Liberal use of new technologies in remote sensing and Geographic Information Systems

Using different climate scenarios, *the ecosystem model can pinpoint in space and time the likelihood of future fires, as depicted in this 3-D simulated fire map. Although actual events will vary with future climate trends, the model provides park managers with sneak previews of park landscapes to aid decision making today.*

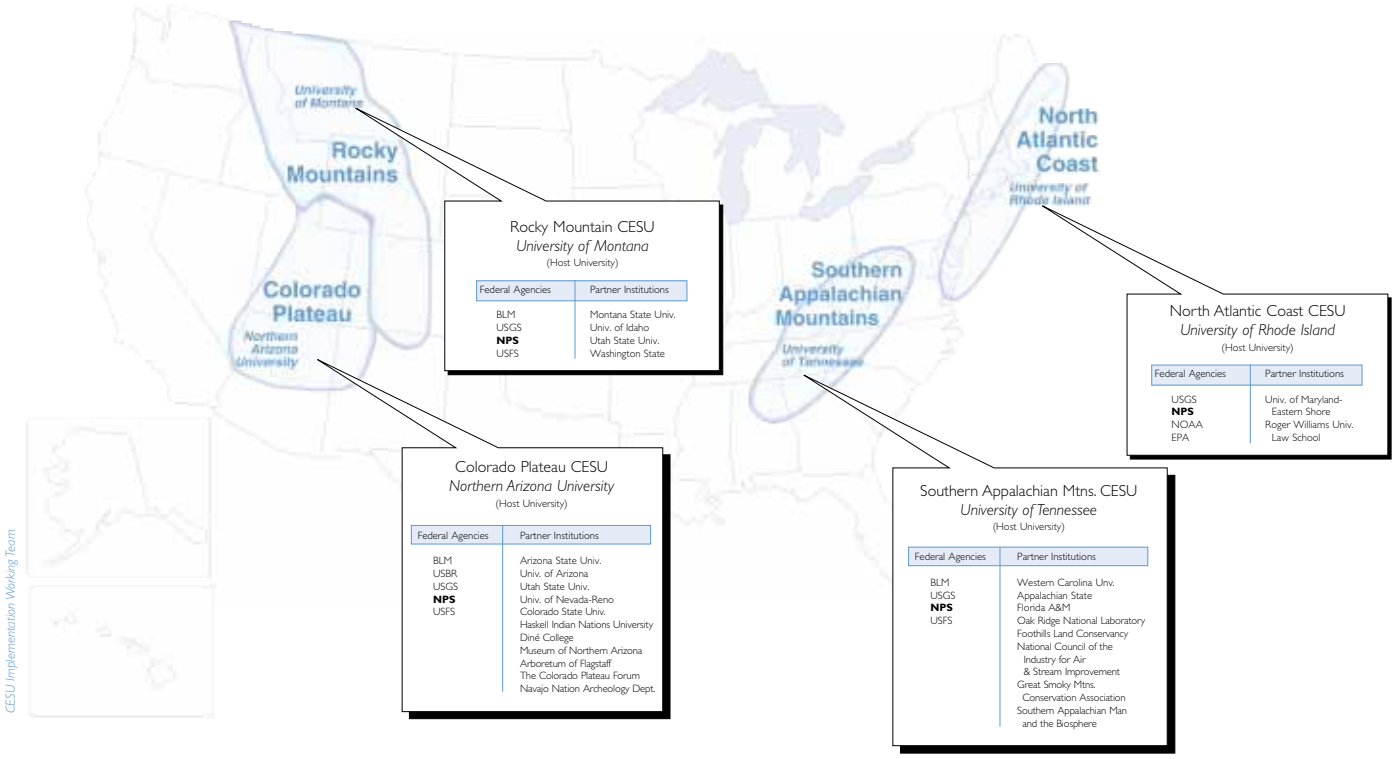
Research scientists monitor climate changes *in Glacier National Park using automated weather stations, such as this one located above St. Mary Lake. The data are used with the ecological models to estimate responses of natural resources to future climate change.*

were combined with the models to produce quantitative estimates, 3-D maps, and computer animations of ecosystem dynamics. Using information from satellites and digital representations of landscapes, the team built interactive computer models to estimate ecosystem attributes such as tree distribution, density, and size. In addition to predicting these and other physical attributes, the models can estimate how the parts interact. For instance, once climate data were incorporated, the models calculated and displayed daily estimates of snowpack density, soil moisture, evapotranspiration, stream discharge, and other dynamic ecosystem attributes for a 150 square-mile mountain watershed. Thus, for any part of the park on any given day, it is now possible to predict specific measures of the ecosystem's condition.

To ensure that the computer-based view of the ecosystem was accurate, key ecosystem outputs such as stream discharge were monitored for seven years and results were compared to model outputs. Close matches between computer-estimated and actual ecosystem measurements suggested that the park's basic responses to climate were accounted for by the models. This means that future climate scenarios can be put into the models to reveal how this ecosystem might look and act in the future. With a future 30% increase in precipitation and a slight increase in annual average temperature (the most likely climate scenario for Glacier within 50 years), the cedar-hemlock forests are favored to expand in lower elevations while accumulation of coarse woody debris and other forest responses should increase the frequency of large, stand-replacing forest fires in other areas. Testing slightly different future climate conditions, the team found that stream temperatures rise earlier in the summer, altering the abundance and distribution of stream organisms, while subalpine fir trees become more nitrogen-stressed at tree line.

Will such changes really occur? Glacier's ecosystem has already altered in response to climate change. One of the most visually dramatic changes is the shrinkage of glaciers, which in turn affects other parts of the ecosystem. Fewer than one-third of the glaciers present in 1850 still exist today, and most remaining glaciers are mere remnants of their previous size. Such irrefutable evidence of climatic change is one reason why Vice President Gore chose Glacier's backdrop in September 1997 to underscore his views on the serious threats of climate change to U.S. citizens.

Although we can never know exactly what the future holds, the capability to evaluate numerous scenarios can result in better decision making now. The models can identify which parts of the ecosystem most readily respond to change, suggesting that monitoring efforts be focused on those areas as early indicators. Similarly, some ecosystem components change more profoundly than others, which can suggest priorities for monitoring and management. Finally, the consequences of management activities such as fire suppression, under future climate scenarios, can be evaluated for unintentional effects or for cost-effectiveness.



Pilot biogeographic areas *of the Cooperative Ecosystem Studies Units (boundaries approximate).*

Acquiring Research

PROGRESS ESTABLISHING COOPERATIVE ECOSYSTEM STUDIES UNITS

by Jared D. Ficker and Dr. Gary E. Machlis

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More than ever before, resource managers need rigorous science and responsive technical assistance in order to make sound management and policy decisions. Agencies must work together to address complex environmental issues that transcend administrative boundaries. Federal agencies are working to devise efficient ways to share resources and expertise.

The National Park Service has been active in an interagency working group to establish Cooperative Ecosystem Studies Units (CESUs). CESUs will provide research, technical assistance, and education to federal land management, environmental, and research agencies. They will also provide support in the biological, physical, social, and cultural sciences needed to address natural and cultural resource issues and interdisciplinary problem solving at multiple scales and in an ecosystem context. Participating agencies include the Bureau of Land Management, the Bureau of Reclamation, the USGS Biological Resources Division, the U.S. Forest Service, the Department of Energy, and the National Oceanic and Atmospheric Administration.

The objectives of the CESU network are to:

1. provide resource managers with high-quality scientific research, technical assistance, and education;
2. deliver research and technical assistance that is timely, relevant to resource managers, and necessary to develop and implement sound adaptive management approaches;
3. ensure the independence and objectivity of research;
4. create and maintain effective partnerships among the federal agencies and universities to share resources and expertise;
5. take full advantage of university resources while benefiting faculty and students;
6. encourage professional development of federal scientists; and
7. manage federal science resources efficiently.

These entities will function as "virtual" organizations, linking several institutions to increase federal access to expertise and facilities. Each CESU consists of several federal agencies, a host university, and partner institutions that bring additional expertise to the CESU to complement the skills of the host university. Each CESU also includes at least one university that primarily serves minority students or that attracts minority students to its environmental science programs. A role and mission

statement, and annual and strategic plans will guide the activities of the CESU. A managers' committee provides feedback and advice from the field.

Through a formal competition in 1998, four pilot CESUs were selected by the interagency CESU Implementation Working Group. They are being established for the following biogeographic regions: (1) the Colorado Plateau, hosted by Northern Arizona University; (2) the Rocky Mountains, hosted by the University of Montana; (3) the Southern Appalachian Mountains, hosted by the University of Tennessee; and (4) the North Atlantic Coast, hosted by the University of Rhode Island.

Selected NPS employees will be stationed for duty at CESUs. Cooperative agreements will allow the National Park Service to efficiently transfer funds to the host universities or partner institutions for research, technical assistance, and education, while maintaining authority and oversight of NPS activities with a CESU. Additional CESUs will soon be established. CESUs are powerful new tools for NPS managers as they work to partner with other agencies to integrate the results of science into NPS decision making.

NPS ESTABLISHES SOCIAL SCIENCE RESEARCH CENTER

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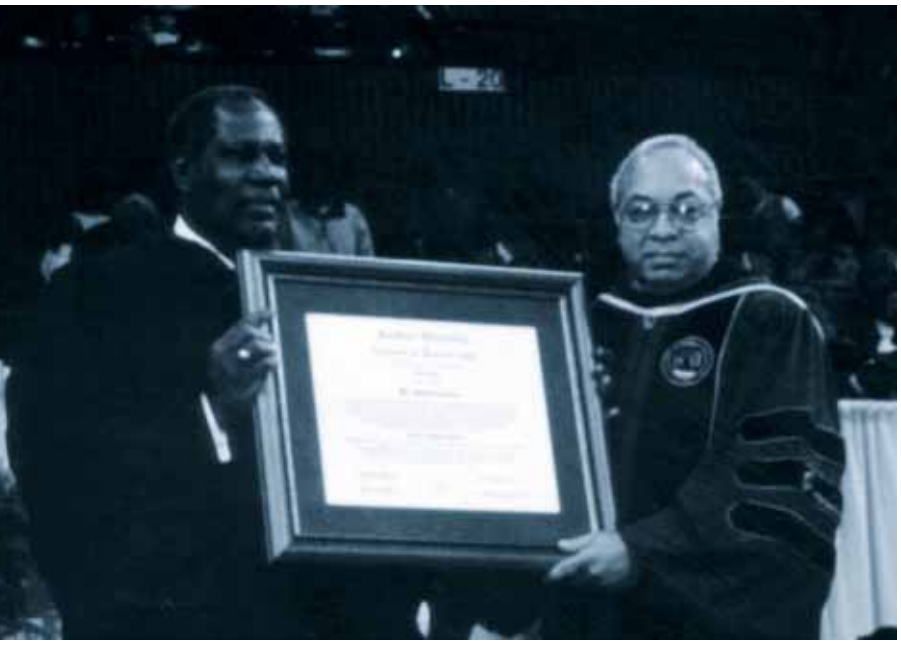
More than 40% of visits to the national park system are to urban sites. The National Park Service plays an important role in shaping the environment, civic life, cultural heritage, economy, and future of the nation's cities. This role must be based on sound stewardship of resources and an accurate understanding of the relationship between people and parks. Hence, social science research related to urban park management is a necessary and important function of the National Park Service. The Urban Recreation Research Center was first proposed in the NPS social science plan, "Usable Knowledge," and approved by the Park Service in 1996. In 1998 the Urban Recreation Research Center was established at Southern University and A&M College, a "historically black college or university."

The objectives of the Urban Recreation Research Center are (1) to assist managers of urban NPS sites in protecting resources and providing visitor services through a program of social science research, technical assistance, and education; (2) to create a wider diversity of scientists conducting research on urban recreation and increase the pool of minority students interested in NPS careers; and (3) to provide technical support to NPS partners to strengthen the role of parks in urban communities. Research conducted by the center will contribute significantly to visitor services and education programs at sites in major cities, such as New York, Los Angeles, Washington, D.C., Philadelphia, Atlanta, and New Orleans. Faculty and students at the center will examine the needs of urban youth for recreation and environmental education, problems related to high-density visitation, and ways to make parks more meaningful to people with different cultural and ethnic backgrounds. The center will also advise the National Park Service on federal programs providing technical assistance to cities to create local parks and urban greenways.

The Urban Recreation Research Center is located in the School of Public Policy and Urban Affairs at Southern University and A&M College. Dr. Ron Harris of the faculty is the director of the new center. The center will make a difference in urban parks by providing usable knowledge to help managers conserve the natural, cultural, and recreational resources of the nation. Several faculty members have a part-time appointment with the Urban



NPS Director Bob Stanton *(left) received an Honorary Doctorate in Public Policy and Urban Affairs last December from Southern University System President Leon R. Tarver II and Southern University and A&M College Chancellor Edward R. Jackson (not shown) at the campus in Baton Rouge, Louisiana. Director Stanton also delivered the commencement address, inaugurating the Urban Recreation Research Center.*

Recreation Research Center: Dr. Alfredo Lorenzo (urban forestry), Dr. Patricia Melson (recreation and leisure), and Dr. Christie Onwujuba (public administration). Several graduate students will serve as research assistants; one is serving as an intern with the Social Science Program in Washington, D.C., beginning January 1999. The NPS Visiting Chief Social Scientist, Dr. Gary Machlis, has been appointed as Adjunct Professor of Public Policy and Urban Affairs and will work with the faculty, present guest lectures, and advise students. In December, NPS Director Stanton toured the Urban Recreation Research Center, met with faculty and students, and delivered Southern University's winter commencement address.

SCHOLARSHIP PROGRAM COMPLETES SECOND YEAR

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In 1998, the Canon National Parks Science Scholars Program named its second class of Ph.D. scholarship recipients. These scholars represent some of the country's best university students working in conservation, environmental science, and park management. Each Canon Scholar receives $25,000 per year for up to three years to conduct research important to the future of the national parks.

The Canon National Parks Science Scholars Program is underwritten by Canon U.S.A., Inc. Other collaborating organizations include the National Park Service, the National Park Foundation, and the American Association for the Advancement of Science (AAAS). The Natural Resource Stewardship and Science directorate coordinates the program. Each year the associate director, drawing on suggestions from park superintendents, selects research questions in four areas: biological, physical, social, and cultural sciences. The American Association for the Advancement of Science assembles scientific panels to evaluate submitted proposals and select the winners. The National Park Foundation transfers scholarship funds provided by Canon for tuition, fieldwork, a stipend, and other expenses. The students must complete a dissertation, prepare an article for park managers on the significance of their research, and present a public lecture about their work.

The 1998 Canon Scholars are Elizabeth Barrie (Indiana University), Kurt Menning (University of California, Berkeley), and Karen Short (University of Montana). Barrie will investigate the meaning of interpretive experiences at Yellowstone National Park. Menning will study the landscape-level effects of restoring fire at Sequoia National Park. Short will explore the effects of fire on understory birds at Saguaro National Park and Chiricahua National Monument.

In 1999 the Canon National Parks Science Scholars Program will be expanded, with eight new Canon Scholars selected each year through 2001. It is expected that members of the first class of Canon Scholars will complete their research by 2000. In total, Canon U.S.A. has made a five-year, $2.5 million commitment to the development of young scientists. The Canon National Parks Science Scholars Program is poised to become one of the most important and prestigious fellowships in the fields of conservation, environmental science, and park management.

Held last fall at the headquarters of the American Association for the Advancement of Science in Washington, D.C., the Canon National Parks Science Scholars Program awards ceremony was also the venue for the first annual Canon Lecture on Science and the National Parks. The 1998 lecturer was Dr. Daniel Janzen, professor of conservation biology at the University of Pennsylvania. In his lecture, Dr. Janzen called for increased "bioliteracy" and the development of widely accessible science databases.

Attending the Canon National Parks Science Scholars awards ceremony *were (from left to right) 1998 Canon Scholars Karen Short and Kurt Menning; AAAS Executive Officer Dr. Richard Nicholson; Canon U.S.A., Inc., President and CEO Mr. Haruo Murase; NPS Director Bob Stanton; 1998 Canon Scholar Elizabeth Barrie; and Mr. James Leiby, Government Marketing Division, Canon U.S.A., Inc. The ceremony took place at AAAS headquarters in Washington, D.C., in November.*